Quality Assurance Tests for RE4

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on behalf of the RPC-TC Team

A full central control on the production at the level of components & chambers:

1.) *Definition of a common QA frame among the assembly sites, subcontractors, suppliers*
2.) *QA definition for each step of the production*
3.) *Documentation*

➔ **Guarantee Reliability + Traceability**

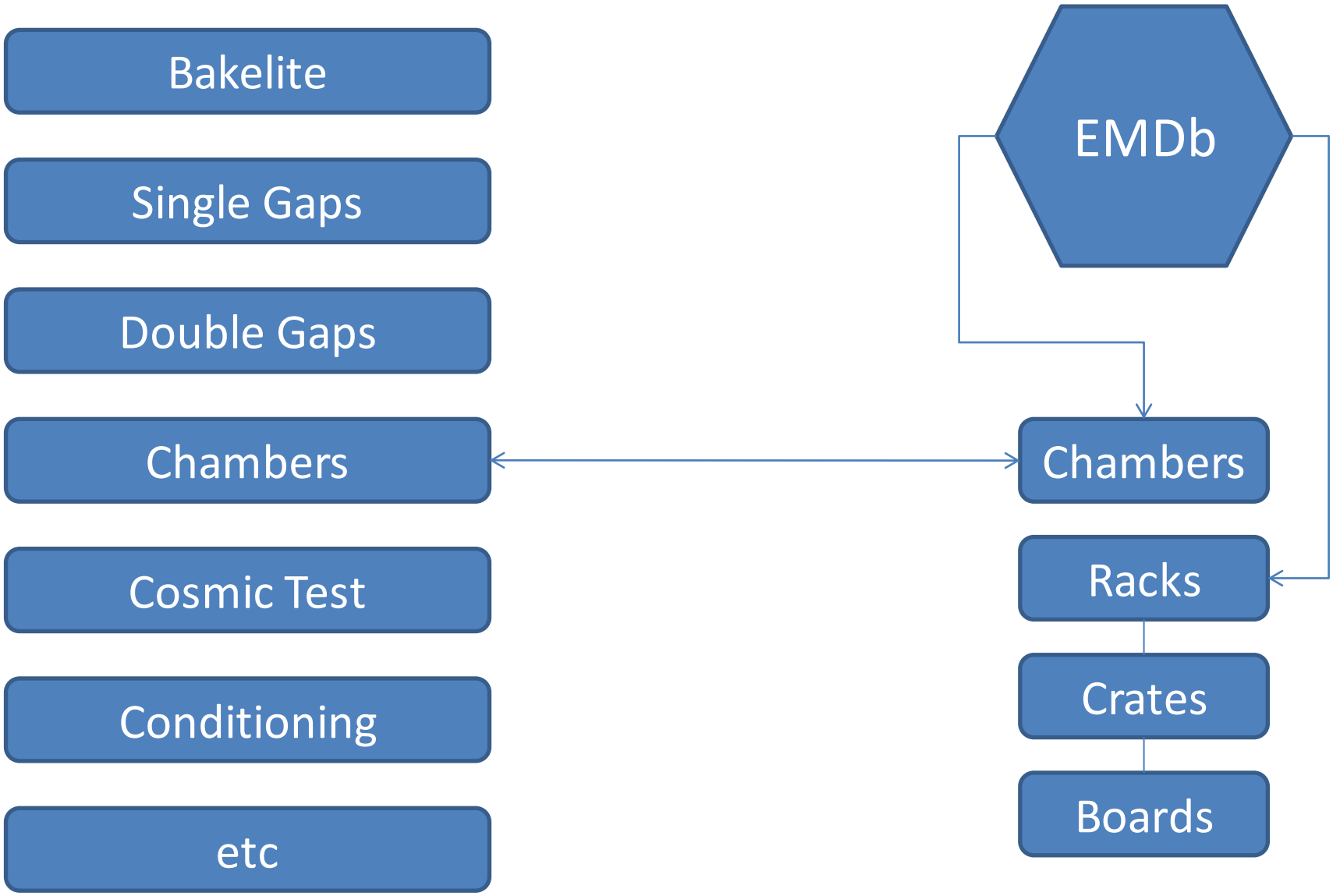
Based on the valuable experience (Barrel & Endcap) we define several steps of QC :

- **QC-1 : Components**
- **QC-2 : Gaps**
- **QC-3 : Chambers (Assembly sites)**
- **QC-4 : Chambers & Super Modules (904)**
- **QC-5 : Commissioning at P5**

For each step :

- **QA protocols to assure manufacture process reliability**
- **QC protocols to select the "good" objects which are inside the technical specifications ranges**
- **Documentation protocols : RPC Construction DB**

ConstructionDB



Responsibilities

- QC-1 : RPC-Technical Coordination
- QC-2 : Kodel + Assembly sites
- QC-3 : Assembly sites
  (CERN, Mumbai, Ghent)
- QC-4 : RPC-Technical Coordination
  (904 team)
- QC-5 : RPC- Technical Coordination
  (Commissioning team @P5)

QC-1 :

Bakelite (HPL panels)
Front End Boards
Distribution Boards
Adaptor boards

QC-1 : Bakelite

Panels 1.6m x 3.2m: (660)

Production site : resistivity, thickness, roughness →

Pavia : Resistivity, Color code, Labeling & DB →

RIVA : HPL Cutting into 3 pieces: V.I. size & corners →

GT : Polishing surface : Visual Inspection surface quality → Shipment to CERN

CERN : Visual Inspection and Final Acceptance if OK → Shipment to KODEL

END of CERN BAKELITE ORDER

QC-1 : Bakelite

- ✓ Production Batch – all the data valid for a complete batch of up to 50 bakelites (craft paper, weights, number of papers, press thermal cycle details etc.)
- ✓ Puricelli Data – primary data from Puricelli are to be uploaded in the database (temperature, humidity, resistivity, st.dev.resistivity, resolution)
- ✓ Pavia Data – measurements in Pavia uploaded in database (on top of the main measurements color code and accept/reject fields are added)
- ✓ Multiple Bakelite Measurements – structure for multiple measurements (multiple measurements are foreseen for the small/cut pieces)

Bakelite Code	Production Number	Production Batch	Slot	Position	Thickness	Measure Date	Temperature Measure	Humidity	Rho20	Sigma Rho20	Resolution	Comments	User	Modified on
2A07a110411010153	153	7	A	2		2011-04-15 00:00:00	18.8	38.45	1.17	0.12	0.10		UZUNOVA	2011-05-11 12:19:20
2A07a110411010153	153	7	A	2		2011-05-22 00:00:00	18.8	38.45	1.17	0.12	0.10		UZUNOVA	2011-05-11 17:20:48
3A07a110411010154	154	7	A	3		2011-04-15 00:00:00	18.8	38.37	1.21	0.17	0.14		UZUNOVA	2011-05-11 12:19:20
3A07a110411010154	154	7	A	3		2011-04-13 00:00:00	18.8	38.37	1.21	0.17	0.14		UZUNOVA	2011-05-11 17:20:48
5A07a110411010156	156	7	A	5		2011-04-15 00:00:00	18.8	38.20	2.00	0.32	0.16		UZUNOVA	2011-05-11 12:19:20
1B07a110411010157	157	7	B	1		2011-04-15 00:00:00	18.8	38.95	1.97	0.36	0.19		UZUNOVA	2011-05-11 12:19:20
2B07a110411010158	158	7	B	2		2011-04-15 00:00:00	18.8	38.87	1.64	0.32	0.19		UZUNOVA	2011-05-11 12:19:20
3B07a110411010159	159	7	B	3		2011-04-15 00:00:00	18.8	38.78	1.34	0.21	0.16		UZUNOVA	2011-05-11 12:19:20
4B07a110411010160	160	7	B	4		2011-04-15 00:00:00	18.8	38.70	1.13	0.23	0.20		UZUNOVA	2011-05-11 12:19:20
5B07a110411010161	161	7	B	5		2011-04-15 00:00:00	18.8	38.62	1.09	0.13	0.12		UZUNOVA	2011-05-11 12:19:20
1C07a110411010162	162	7	C	1		2011-04-15 00:00:00	18.8	39.37	4.57	1.08	0.24		UZUNOVA	2011-05-11 12:19:20
2C07a110411010163	163	7	C	2		2011-04-15 00:00:00	18.8	39.28	3.66	0.82	0.22		UZUNOVA	2011-05-11 12:19:20
3C07a110411010164	164	7	C	3		2011-04-15 00:00:00	18.8	39.20	2.93	0.58	0.20		UZUNOVA	2011-05-11 12:19:20
4C07a110411010165	165	7	C	4		2011-04-15 00:00:00	18.8	39.12	2.40	0.70	0.29		UZUNOVA	2011-05-11 12:19:20
5C07a110411010166	166	7	C	5		2011-04-15 00:00:00	18.8	39.03	2.05	0.44	0.22		UZUNOVA	2011-05-11 12:19:20
1D07a110411010167	167	7	D	1		2011-04-15 00:00:00	18.8	39.78	8.72	2.91	0.33		UZUNOVA	2011-05-11 12:19:20
2D07a110411010168	168	7	D	2		2011-04-15 00:00:00	18.8	39.70	7.48	2.08	0.28		UZUNOVA	2011-05-11 12:19:20
3D07a110411010169	169	7	D	3		2011-04-15 00:00:00	18.8	39.62	6.59	1.74	0.26		UZUNOVA	2011-05-11 12:19:20

QC-1 : FEB (Pakistan)

Dedicated format file is to be filled and uploaded in the DB before shipment ; if OK→ shipment to CERN

- FEB_ID (CMS barcode)
- Time_Code
- Delay_ns
- Date and Time of Test
- Test_Bench (or Manufactored by)
- Specification File (the output of the labview program in jpeg or png format)
- 4 Values Hardware THR 1, THR 2, THR 3, THR 4
- 4 Values Vmon1, Vmon2, Vmon3, Vmon4
- Comments

QC-1 : Distribution Boards

Dedicated format file is to be filled and uploaded in the DB before shipment ; if OK→ shipment to CERN

- Serial ID (CMS barcode)
- Date and Time of Test
- Site

QC-1 : Adaptor Boards

Dedicated format file is to be filled and uploaded in the DB before shipment ; if OK→ shipment to CERN

- Serial ID (CMS Barcode)
- Date and Time of Test
- Site

QC-2 : Gaps (Kodel)

Supplier : Kodel 660 Gaps / 12 months

Very clear Gap specifications document :

- -Detailed QA procedures
- -Clear acceptance Protocol including the instrumentation to be used

Upgrade Gap Structure and GUI in RPC construction database ready

Verification of the data for each gap

if OK then shipment to the 3 assembly sites

one shipment /month, 12 shipments in total

~60 gaps/month

QC-2 : Gaps (sites)

Final Acceptance tests : Assembly sites

Ready :

-QA procedure & QC tests

-Tooling (handling of the gaps)

-Instrumentation

-Electronics

Under Development :

Software Tools (scripts)

Gap stands :

CERN 10 slots ,U-Gent :5 slots,Mumbai :3 slots

QC-2 : Gaps (sites)

Type of tests:

Visual Inspection.

Gas Tightness tests,

Spacers Test

Electrical & Dark currents Test

Resistivity measurement (only in the sites)

All HV values are corrected for P &T

P_0=1010mbar, T_0=293K

Construction Database :

Gap passport

Data verification algorithms applied for data import of all Gap Quality Certification Tests.

QC rejection criteria implemented

Storage area in a controlled Environment

Visual Inspection	Bending, thickness, HV connections, inlets outlets PET film condition, graphite uniformity (?) Report 2x (HPL Serial numbers + Resistivity color)	Equip each gap with Jupiter male connector , length of HV cable =0.75 m Report Data for all gaps Gaps stored in T (18-25) & humidity (25- 50%) controlled environment
Leak test	@ 20 mbar, @ 5 mbar only for Ref. value for chamber leak	Threshold (@20mbar) Leak rate < 0.2mbar/10min @ 2 liters
Spacers	@ 20mb	All spacers properly glued, 0 broken
Dark current test I	I vs HV plot waiting time 20 min per point Gas mixture : standard, Flow =5 l/h, 48 hours P , T correction online	1,2,3,4,5,6,7,7.5,8,.8.5,9.0,9.1, 9.2,9.3,9.4,9.5,9.6,9.7, 9.8. 9.9, 10., 10.1 HV values @ 1010 mb & 293K Gap rejected if : $I_{10KV} > I_{max}$ Pressure, T and Humidity
Dark current test II	I drawn @ HV=10.0 KV 24 hours period (normalized) registered Script to adjust HV vs (P, T) automatically	Gap rejected if at the end : $I_{10KV} > I_{max}$ or I_{10KV} Increase > 50% or OVC,Spikes of current present.

Dark current III	**Check the ohmic component →** **study correlation I_{6KV} vs $I_{9.5KV}$** Waiting time 5 min **Barrel gaps with I_{6KV} >1 uA rejected**	**At the end of Dark current II test perform HV ramp-up: 1,2,3,4,5,6,7,7.5,8,.8.5,9.0, 9.1,9.2,9.3,9.4,9.5,9.6,9.7, 9.8. 9.9, 10., 10.1** **Record P, T** **→ $I_{6KV} < I_0$** **Register the data**

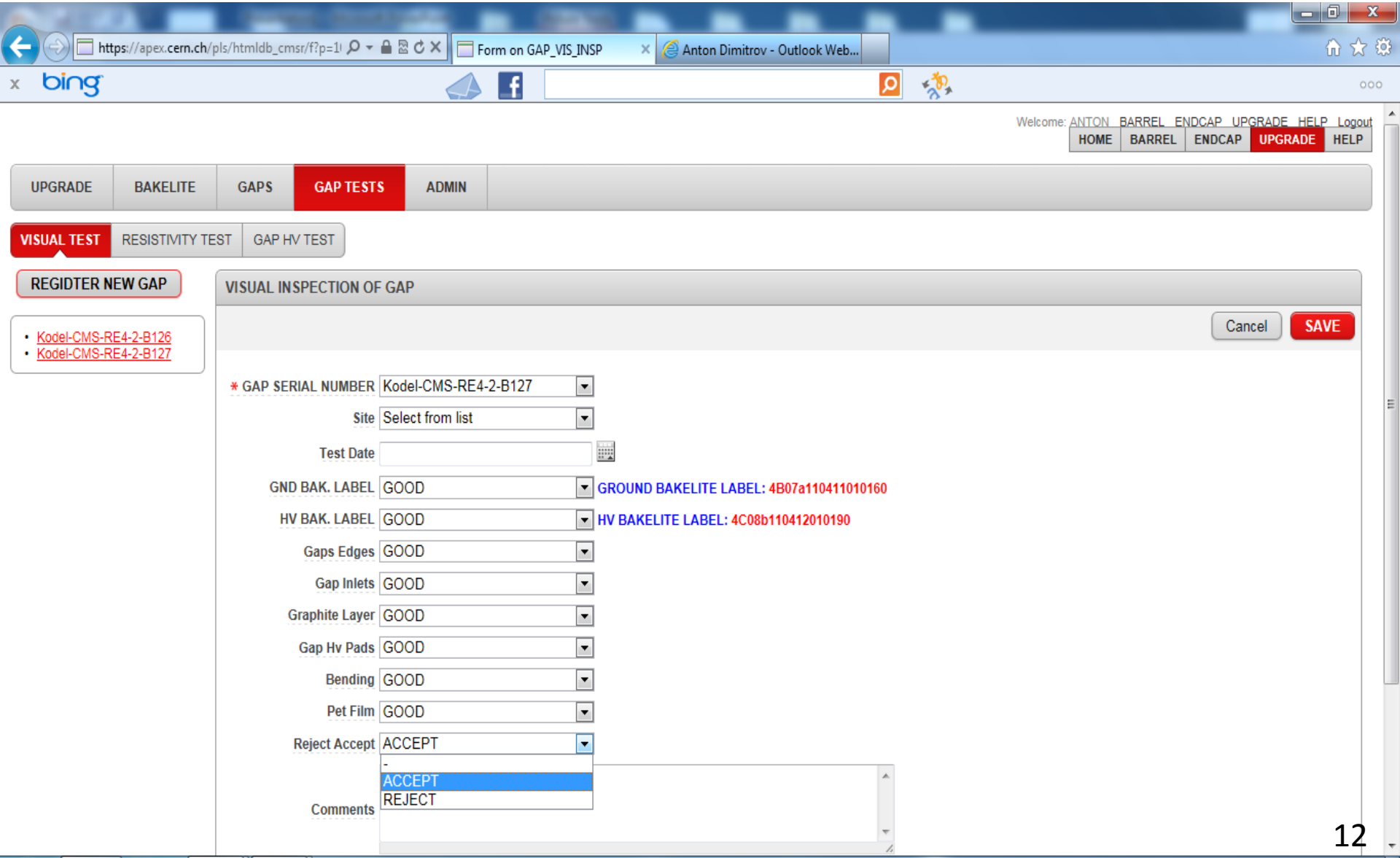
Barrel : At the end of QC-2 : 8.5 % of gaps had been rejected

Gap Visual Inspection

HV Bakelite Barcode Label
GND Bakelite Barcode Label
HV cable (new)
GND cable (new)
HV block (instead of Gap HV Pads)
GND connection (new)
HV Graphite Layer
GND Graphite Layer
HV PET Coating
GND PET Coating
Edges and Gas Corner Piece (instead of Gap Edges)
Gas Inlets and Outlets (instead of Gas Inlets)
Bending
Reject_Accept
COMMENT

➔ **ConstructionDB**

VISUAL INSPECTION PROTOCOL



Electrical tests

- Gas :
  95%Freon +5% Iso @Kodel
  95.2%Freon + 4.5%Iso + 0.3%SF6 + 40%(Humidity)

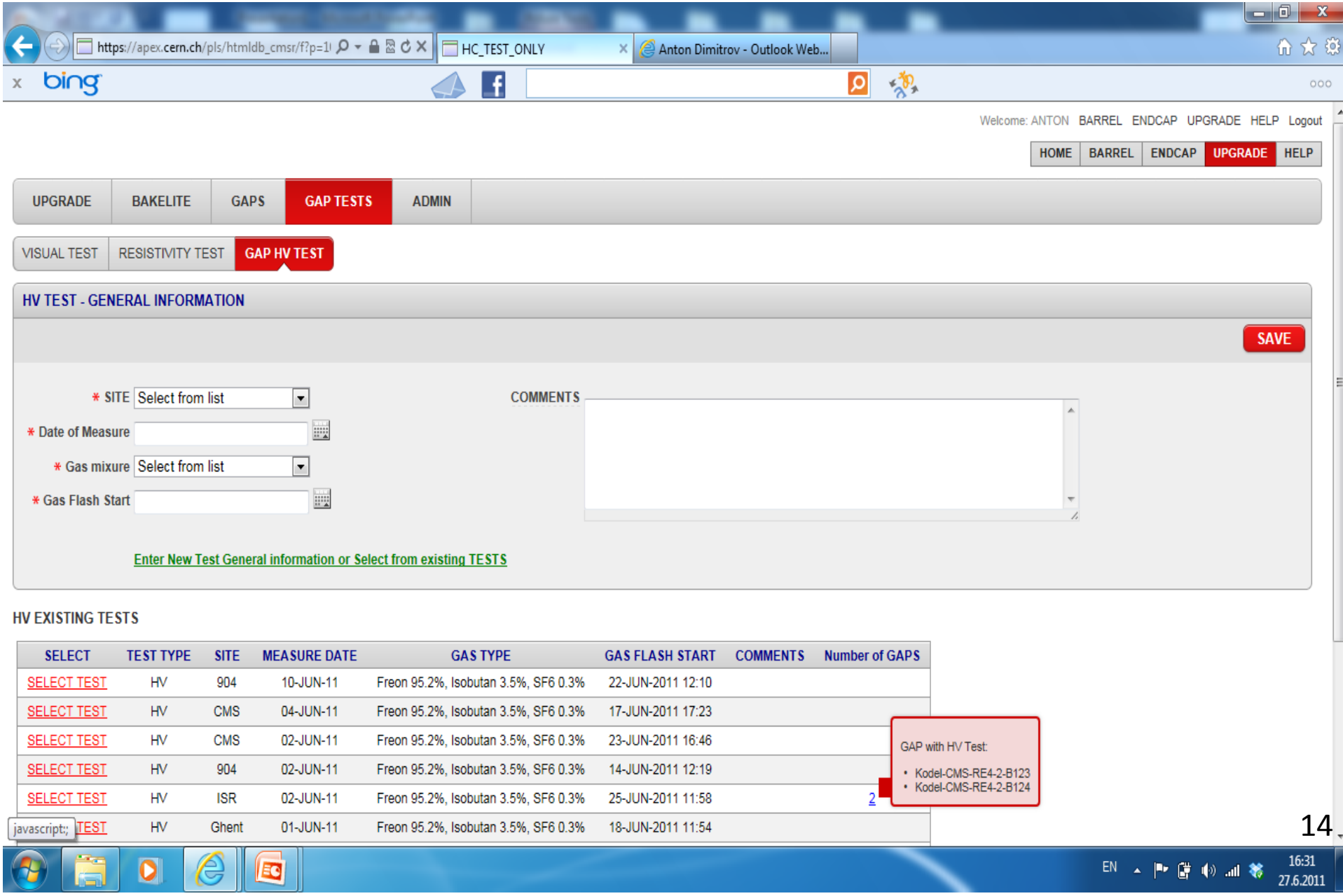
- Maximum Value of the current (9.5KV @Kodel, 10KV @A.S.)

Gap Type	RE4/3 "top narrow"	RE4/3 "top wide"	RE4/3 "bottom"	RE4/2 "top narrow"	RE4/2 "top wide"	RE4/2 "bottom"
I_{max} (μA)	3.5	2.0	5.0	2.0	2.0	3.5

Maximum Value of the current @ 6KV:

(1.5uA@Kodel, 0.5uA @A.S.)

GAP TESTS: HV TEST



Leak Tests

- The gas tightness is controlled by measuring the stability of an applied overpressure of 20 mbar in a fixed time of 600 seconds using a pressure sensor (Sensor Technics CTE7000) and a 20 bit ADC Picolog recorder with 20 bit resolution.
- Acceptable pressure drop values are defined as function of the Gap Volumes:

  With the Water Column Method, for a Volume of 2 liters the acceptable drop of the water level is 1 mm /600sec, is equiv. to 0.2mbar/600sec = 6.6 10*-4 [mbar.l/sec] which is 0.7 times less than the BS EN13184:2001 Standard acceptable leak rate (=10*-3[mbar . l/sec]).
- Leak measurement @ 5mbar taken as reference value for the chamber leak test

Spacer strength test

The Gaps are subjected to an overpressure of 20 mbar to check the spacers tightness.

A mask made of 0.2mm thick PET film, where the shape of the spacers and the positions are properly drawn, is positioned on the gap.

A 20 hPa pressure is applied to the gap. Each spacer is pressed and the variation of the pressure is reordered .

The gas gap is qualified when no spacer causes a shift larger than 1 mbar.

All the data will be recorded in the DB

Gap Passport

GAP PASSPORT - Mozilla Firefox

Fichier Édition Affichage Historique Marque-pages Outils ?

https://apex.cern.ch/pls/htmldb_cmsr/f?p=106:135:945165773257693:GAP:NO::P135_GAP_ID,P135_GAP_SN:22

GAP PASSPORT | GAPS OVERVIEW | REGISTER NEW GAP | DEFINE GAP TYPE | DEFINE GAS MIXURE | DEFINE HW TOOLS

GAP SERIAL NUMBER
TEST_GAP_10

GAP TYPE
B/SIZE 2

Size: Volume/ Active area
Size 2: 2.339/ 1.169

GROUND BAKELITE
11

HV BAKELITE
9

MANIFACTURED BY
KODEL

PRODUCTION DATE
01/04/2011

Shipment Date (Assembly)
07/07/2011

Reception Date (Assemly)
23/07/2011

Assembly Site
904

GLOBAL RESULT
NOT TESTED

SELECT GAP

- TEST_GAP_1
- TEST_GAP_10

VISUAL INSPECTION - Latest Test

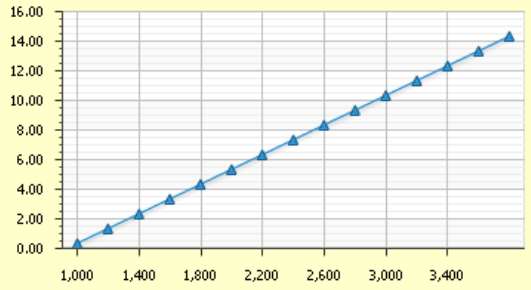
TEST_DATE	SITE	REJECT ACCEPT	GRN BAK LABEL	HV BAK LABEL	Hv Cable	Gnd Cable	HV block	GND Conn.	HV Graphite Layer	GND Graphite Layer	HV PET Coating	GND PET Coating	Edges & Gas Corner	Gas Inlets & Outlets	BENDING	COMMENTS
25-JUL-11	CMS	ACCEPTED	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	-

LEAK TEST - Latest Test

TEST DATE	SITE	REJECT ACCEPT	Test Pressure	Hardware Tool	Overpressure	Bad Spacers	Slope	Slope /10min	Leak Rate	COMMENTS
01-NOV-11	CMS	ACCEPTED	20	Tool1	20	0	-.00000057	-.342	-.00133266	-

Bloquer...

RESISTIVITY TEST



TEST ID	26
TEST TYPE	RESISTIVITY
SITE	CMS
DATE	13-OCT-11
GAS MIXURE	Freon 94.7% + Isobutan 5% + SF6 0.3%
GAS FLASH START	11-OCT-2011 17:16
ALPHA	1

TEST RESULT: ACCEPTED

QC-3 : Chambers (sites)

QC-3-1 :

Chamber Assembly

QC-3-2 :

Performance Assessment of the detector with Cosmic Rays

QC-3-1 : Chamber Assembly (Sites)

- Very clear documentation how to build a chamber & QA procedures have been established and sent
- Training sessions : 4 chambers built in February/March
- Exhaustive list of all the chamber's components established
- List of all the equipments & components for the infrastructure of the 3 sites
- All components have been centrally purchased (cern)
- Distribution among the 3 sites is on going
- Clear QC procedures for the chamber validation

QC-3-1 : Chamber Assembly (Sites)

- **Clear QC procedures for the chamber validation before the performance assessment**:
  - mechanics,
  - gas tightness
  - Cooling tightness
  - Electrical tests / GAP (jupiter HV connectors)
  - Electronics ON tests
  - Strip Connectivity

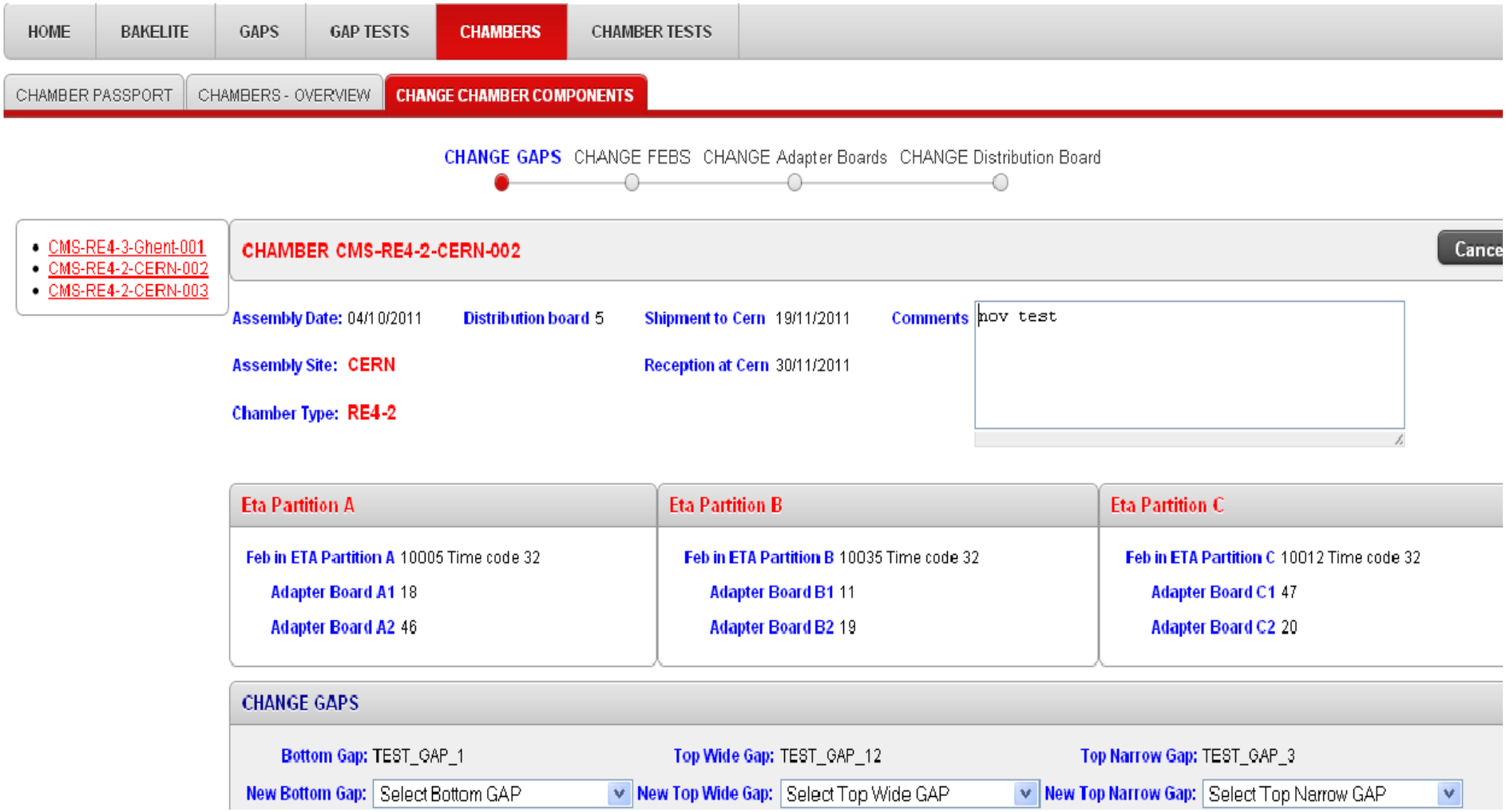
- **Construction Database :**
  - Chamber passport
  - Data verification algorithms applied for data import of all Quality Certification Tests.
  - QC rejection criteria implemented

Electrical tests I (LVs)	**LV analog = 7V** **LV digital = 7.5 Volts**	**Ianalog < 0.140 A / FEB connected** **Idigital < 0.260 A / FEB connected** **THR 1,2,3,4 =215 mV** **Vmon 1,2,3,4 =3500 mV**
Electrical tests II (I^2C)	LabView Only One module available Need to secure 4 modules Old components could be difficult to find (M. Tytgat)	Check for each Feb : Write & Read several values of Thresholds (V_{thr}, V_{mon}) 50, 215, 400
Connectivity tests	Pins 33- 40 input pulse LVDS negative Output Pulse / strip duration > 200 ns Only one Frequency meter available (Produce 3+1 : Pigi)	Check if each strip is responding For V_{mon} =3500mV duration of output pulse ~100 ns
Leak test	@ 3 mbar	Cut under study to be defined (gas sector)
Cooling test	Argon @ 20bar	< ΔP =100 mbar / half-hour (to be verified)

QC-3-1 : Chambers Assembly (sites)

Dark current test /GAP (jupiter)	**I vs HV plot waiting time 20 min per point Gas mixture : standard, Flow =5 l/h, 48 hours P , T correction online**	**0.1,1,2,3,4,5,6,7,7.5,8,.8.5, 99.1,9.2,9.3,9.4,9.5,9.6,9.7 , 9.8. 9.9, 10., 10.1 HV values @ 1010 mb & 293K rejected if $I_{10KV} > I_{max}$ Pressure, T and Humidity**
Dark current test II / GAP (jupiter)	I drawn @ HV=9.7 KV 3 days period registered Script to adjust HV vs (P, T) automatically	Gap rejected if at the end : $I_{9.5KV} > I_{max}$ or $I_{9.5KV}$ Increase > 50% or Spikes of current present.

Chamber Components : QC-3-1



QC-3-2 : Performance Assessment(Sites)

Validation of the RPC performance with Cosmic Rays
Chambers placed horizontally in Hodoscope with a controlled Temperature Humidity Environment (T=20,H=35%-55%)

Muon Trigger system generated by 2 layers of scintillators

CMS Gas mixture : 95.2%Freon+4.5%Iso+0.3%SF6 +40%(Humidity)
Gas T & Humidity monitored

DAQ : VME based, TDV Caen V1190A-128 ch in all 3 sites

On-line : CERN & BARC same software (cern)
U-Ghent different (VME bridge)
status : under Development

Off-line : the same software in the 3 sites (CERN team)
status :under development

QC-3-2 : Performance Assessment(Sites)

- **Check for noisy & absence of dead strips**
- **Performance Assessment per Gap and Global**

Chamber performance under discussion…	**Cosmic rays** **Hodoscope**	**HV=8.7,8.8,8.9 ,9, 9.1,9.2,9.3,9.4, 9.5, 9.6,9.7, 9.8, 9.9, 10., 10.1 KV** **@ (1010mb, 293K), THR=215mV** **Plots:** **Efficiency, noise rate, noise profile, cluster size, strip multiplicity, number of clusters, strip profile, streamer, dark current**

Construction DB in progress

Certification Rate : One Stand / month

CHAMBER PASSPORT

Chamber_Construction - Windows Internet Explorer

https://apex.cern.ch/pls/htmldb_cmsr/f?p=106:20:3129631994273703::NO::P20_CH_ID,P12_CH_ID:462,462

Favorites | Chamber_Construction

CHAMBER NAME: W-2/RB2 in/1, CHAMBER TYPE: RB2-2in-Right, CHAMBER LOCATION: RPC BARREL, WHEEL -2, SECTOR 1

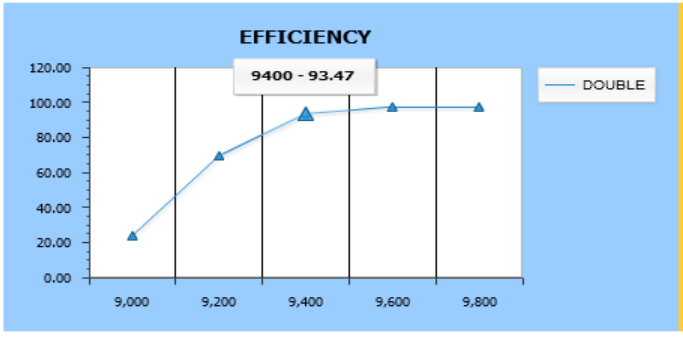
Welcome: UZUNOVA BARREL ENDCAP UPGRADE HELP Logout

HOME | BARREL | ENDCAP | UPGRADE | HELP

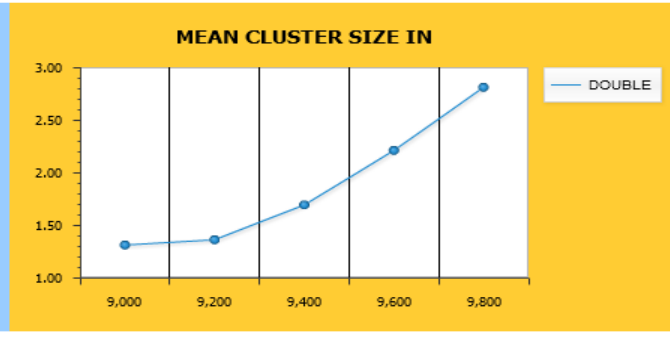
SELECT WHEEL/SECTOR/CHAMBER | CHAMBER PASSPORT | CHAMBERS' ELEMENTS | CHAMBERS' TESTS

CHAMBER ID	CHAMBER NAME	CHAMBER TYPE	SERVICE EXIT
462	W-2/RB2 in/1	RB2-2in-Right	

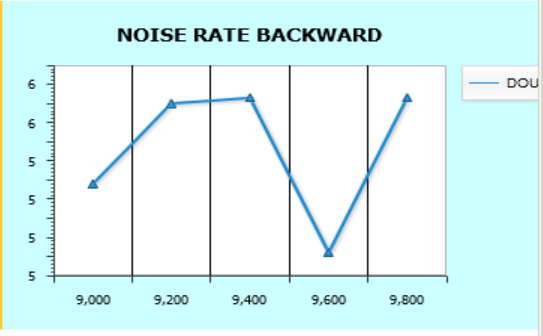
ETA PARTITION: BACKWARD



TEST LOCATION: BARI
DATE of TESTS: 28-AUG-06



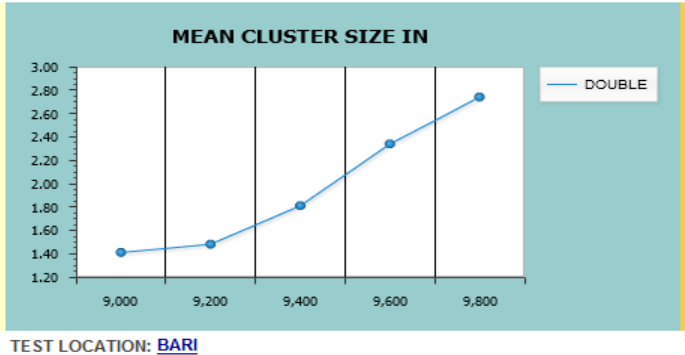
TEST LOCATION: BARI
DATE of TESTS: 28-AUG-06



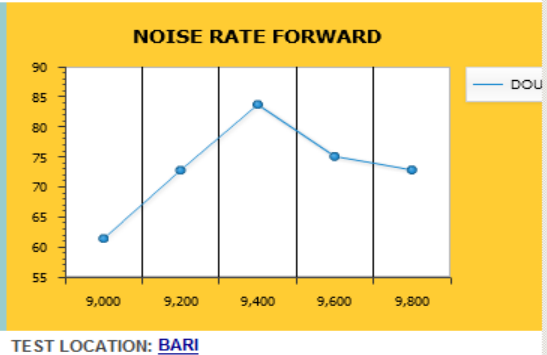
TEST LOCATION: BARI
DATE of TESTS: 28-AUG-06

ETA PARTITION: FORWARD

TEST LOCATION: BARI
DATE of TESTS: 24-AUG-06



TEST LOCATION: BARI
DATE of TESTS: 24-AUG-06



TEST LOCATION: BARI
DATE of TESTS: 24-AUG-06

QC-4 : RPCs (904)

QC-4-1 :

Acceptance tests of the RPCs &
Preparation for P5

QC-4-2 :

Assembly of the SuperModule &
Final Acceptance Test (Long Term)
Before transport to P5

QC-4 : RPCs (904)

- ✓Dedicated area in the 904
- ✓Dark currant, leak, connectivity tests of the chambers before SM
- ✓Assembly of the Super Module :

  mount TWO chambers with similar plateau on the Al Frame
- ✓Gas Leak, cooling test of the SM
- ✓Long term monitoring of the current @ 10 KV

  Gap rejected if at the end: I @10KV > I_{max} or

  I@10KV Increase > 50% or OVC,Spikes of current
- ✓ Final check QC data in the DB

Total time needed for one Super Module :

4 + 1 = 5 weeks (including 20% contingency)

Conclusions (1)

- Bakelite:

  HPL batch # 10,11&13 +12 Measurements are done, data ready to be uploaded
- Electronics ON :

  QC testing established, Under production, DB ready
- Gaps :

  QA & QC established, list of components and equipment established, DB ready , software tools under development
- Chambers Assembly :

  QA&QC established , list of components ready, procurement on going, DB ready,
- RPCs characterization :

  Cosmic stands under construction, Architecture of the Trigger and DAQ defined, online under development, analysis software not yet started (in discussion), cosmic table & interface not ready
- Super Module : QA & QC to be finalized, DB to be developed
- P5 (Instal & com.) : Procedures & tests to be defined (QC-5)

Conclusions (2)

- ✓ Every step of the construction from the bakelite production until the super module certification is maintained under a central control
- ✓ Activities in the different production sites are synchronized through the DataBase
- ✓ Procurement is centralized
- ✓ Documentation and traceability for each component
- ✓ All measurements recorded for each gap & chamber allowing a complete assembly and cosmic test history
- ✓ Construction DB in progress we aim to complet all QC by the end of the year